

cette variabilité au sein du même genre nous oblige à reconsidérer la valeur phylogénétique et évolutive de certains comportements, puisque nous n'avons aucun argument pour décider si, à l'intérieur de ce genre, une ou plusieurs espèces sont plus avancées que d'autres. Au vu de la dualité d'expression qui peut se manifester lors du comportement sexuel (présence ou non de Laufschatz ou de pose du menton sur la croupe), du comportement agonistique (coups de front seuls ou présence simultanée de coups de front et de morsures), ou du comportement social (vie solitaire ou vie plus ou moins permanente avec 1 ou plusieurs partenaires, léchages et marquages mutuels absents ou fréquents, allomimétisme ou non dans les activités, etc. . .), il semble bien que le genre *Cephalophus* se trouve placé à un carrefour évolutif. Chez lui, des comportements très «avancés» peuvent ainsi apparaître selon les espèces et leurs conditions de vie, et il ne semble plus possible de considérer les Céphalophes comme les Bovidés les plus primitifs.

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Zusammenfassung

Verhaltensunterschiede innerhalb der Gattung Cephalophus (Ruminantia, Bovidae) am Beispiel von C. rufilatus Gray, 1846

Im Zoo von Piétat konnte eine auf einem 0,7 ha großen Gelände freilebende Gruppe von 7 *Cephalophus rufilatus* ethologisch untersucht werden. In den meisten seiner Verhaltensweisen unterscheidet sich diese Art nicht von den anderen bereits untersuchten Dackern. Jedoch zum Unterschied von eben diesen Arten zeigt *rufilatus* ein fast völliges Fehlen sozialen Spieles und des sich gegenseitigen Putzens. Vorhanden sind dagegen Beißen und Kopfstöße im Verlauf agonistischer Auseinandersetzungen. Der Laufschatz ist nur rudimentär vorhanden. Das in Brunft befindliche Weibchen besteigt häufig die Gruppenmitglieder. Die Defäkation erfolgt stark lokalisiert in Häufchen. Global betrachtet ist *rufilatus* eine Art mit Tag-Nacht-Rhythmus und zeigt dementsprechend auch ein intermediäres Verhalten. Dies zeigt sich besonders im Sozialverhalten, denn die einzelnen Individuen vertragen sich relativ gut, wenngleich auch jedes Tier seine eigene von den anderen unabhängige Aktivität hat und mit diesen nur ein Minimum inter-individuelle Kontakte hat. Es scheint keine bestimmte Wahl des Partners zu bestehen.

Im großen und ganzen erscheint die Gattung *Cephalophus* relativ homogen in bezug auf fundamentale Verhaltensweisen wie Fortbewegung, Sekretausscheidung, Markierung, Fortpflanzung, usw. Unterschiede dagegen findet man bei allen den Lebensstil betreffenden Verhaltensweisen im Biotop und bei den Aktivitätsrhythmen. Dies alles entspricht recht gut der morphologischen und ökologischen Variabilität dieser Gruppe. Neben Merkmalen, die man als «ursprünglich» bezeichnen kann, findet man auch gewisse höher entwickelte Verhaltensweisen. In diesem Kontext erscheinen die Cephalophinae innerhalb der Bovidae keineswegs als eine der primitivsten Gruppen.

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Systematics and chromosomes of the Indian gazelle, *Gazella bennetti* (Sykes, 1831)

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Abstract

In 3 individuals of *Gazella bennetti* chromosome numbers of $2n = 50$ (♀) and 51 (♂) were found. The structures of the X and Y1 chromosomes differ from other gazelle species. The Indian gazelle must not be classified as a subspecies of *G. gazella* or *G. dorcas*.

Introduction

The genus *Gazella* de Blainville, 1816, has always been a major challenge to the mammalian taxonomist. There is still room for subjectivity in the classification of some members of this group, not only at the subspecies but even at the species level. No common agreement has yet been reached on the number of genuine species within this genus, especially with regard to the "smaller gazelles" (which exclude the subgenus *Nanger*). For example, no final answer can be given to the question whether *Gazella leptoceros* should be regarded as a species of its own or whether it should be incorporated into *Gazella subgutturosa* (as proposed by LANGE [1972]). Another gazelle with an uncertain taxonomic position is the Chinkara or Indian gazelle, *Gazella bennetti* (Sykes, 1831), which was included into *Gazella gazella* by some authors, whereas others considered it as belonging to *Gazella dorcas* (see below for further discussion). As will be shown in this article, neither of these views is correct.

Some of the uncertainties about the classification of smaller gazelles are due to the fact that variation within the units commonly regarded as species, is almost as big as the total range of variation within the remarkably uniform subgenus *Gazella*. There is such an overlap between intra- and interspecific variation both in coloration and cranial morphology that geographical provenience of an individual specimen is often the most important character for its classification – which is certainly not the correct procedure for taxonomic identification. This is particularly true due to human interference with the distribution of gazelles in recent years. Gazelles are favorite pets all over the Middle East and North Africa and there is a flourishing, yet completely uncontrolled trade of live animals over long distances. Thus, the locality where a specimen was obtained by a zoological collector may be far away from the place of origin of the animal. In addition, the trade and keeping of gazelles in one's backyard has an immanent danger of hybridization, which adds to the difficulties of classification.

One possibility to decrease the difficulties of gazelle systematics is to establish the exact geographical ranges of defineable forms prior to the distortions caused by human interference. Bone remains of gazelles are common finds at most archaeological sites in the Middle East and North Africa. Once they can be identified beyond the genus level, these finds have a potential to determine the original range of the respective species. However, except for complete skulls or well preserved fragments thereof, specific identification of isolated gazelle bones is still impossible. To establish criteria for the identification of postcranial bones (apart from the evaluation of differences in absolute size which may have shifted during the recent geological past), it is necessary to increase the number of well identified

reference skeletons. Obviously, this necessity, namely correct taxonomic identification of the reference specimen, brings us back to the difficulties described above.

This article is a first result of some work based on the attempt of one of us (H.P.U.) to build up a comparative collection of gazelle skeletons for palaeo-zoological research. Fairly large breeding groups of different gazelle species kept under the medical care of another of us (C.W.F.) at the zoo of Al-Ain (Abu Dhabi, U.A.E.) were a source not only of skeletal material, they also provided the living tissues to try a 'biological' determination of the taxonomic affinities of the respective populations. As a basic approach, some karyological research was started by the third member of our group (H.T.). It is mainly due to this last part of our work that some contributions to the systematics of gazelles have resulted from this effort. Some gazelles brought from Pakistan to the zoo of Al Ain gave surprising results when tested for their chromosome numbers. Some conclusions on the systematic position of these gazelles will be based on a description of the animals themselves and on the evaluation of their karyotypes.

Material and methods

A group of gazelles captured during a hunting expedition in Pakistan was brought to the zoo of Al-Ain in Abu Dhabi (United Arab Emirates) in 1984. Unfortunately, the exact geographical origin of the animals could not be investigated. It was obvious, however, that they were "chinkaras", which is the local name for the Indian gazelle, *Gazella bennetti*.

The general colour of the animals is a light fawn, almost isabelline. The stripe along the flank is brown, narrow at its origin on the shoulder but increasing in width as it extends along the lower part of the rump. The upper rim of this stripe is not well defined nor is there a well marked zone of lighter coloration above the flank stripe. The lower border of the flank stripe is well marked against the yellowish colour of the ventrum which also extends along the inner thighs of the legs. Like the flank stripe, the pygal stripe is brown, fading into the fawn colour of the back, but contrasting well with the whitish patch on the inside of the thighs. The pygal stripe extends down the sides of the tail, ending in the black of the distal portion of the tail. Other spots of dark coloration are just above the hoofs, particularly between the two digits, and the carpal brushes. The facial stripes are also dark brown in colour, extending from the anterior corner of the eyes finishing just distal to the upper lips. Above and below these stripes, as well as around the eyes and the mouth, the colour is very light. The nasal area between the facial stripes is fawn with a typical dark nose blotch of varying extent. In some animals it is an ill defined brown spot only. Usually it is almost black in the middle with shades of brown towards the edges. Between the eyes, the colour is reddish-fawn. Darker eyebrow stripes reach from the eyebrows to the lateral edges of the horns, fading toward the base of the large ears. The frontal region is lighter again, though not much different from the general colour of the animal.

Compared to most other gazelle species, the markings of our animals are fairly unobscure. This is a known feature of *Gazella bennetti*. In comparison to typical Indian animals of this species, our animals are less reddish, more greyish in total appearance. Specimens from Baluchistan, originally considered to be a separate species (*Gazella fuscifrons*, Blandford, 1873), have a dark coloration of the forehead, not present in our animals. The description available for *Gazella bennetti christyi* Blyth, 1841, which is the subspecies inhabiting the intermediate zone between the two extremes, is too vague to be applied. The "silvery drab-brown" (GROVES 1985) of this subspecies might in fact apply to our animals. However, they could also be called "rich tobacco-brown" which – according to GROVES (1985) – is the coloration of the unnamed subspecies inhabiting the Salt Range and Punjab areas of northeastern Pakistan and northern India. Thus, the better known subspecies *bennetti* and *fuscifrons* can both be excluded, whereas the two less well known races of Pakistan are both possible identifications for the animals used here.

For karyotyping, the blood of three animals was tested: An adult female and its male calf, and an unrelated adult male. Blood samples of 3–5 ml were sent in a heparinized form from Al Ain to Tübingen by air courier. The time span between taking the blood samples and the beginning of cell cultivation was 48 to 60 hours. Cell culture was carried out by isolating lymphocytes over a ficoll paque gradient, and stimulation of mitoses with phytohemagglutinine in RPMI 1640 medium with 15 % fetal calf serum. After 72 hours of culture at 37°C, 5 % CO₂, mitoses were arrested with colchicine. Metaphase chromosome spreads were prepared after hypotonic treatment and fixation in methanol/acetic acid (3:1) by routine air dry techniques. For identification, the metaphases were stained with orcein, and for the characterisation of constitutive heterochromatine, the C-banding technique was used (SUMNER 1972).



Fig. 1. Young male of *Gazella bennetti* from Pakistan in the quarantine station of Al Ain Zoo

Results

For the three animals under consideration we found a diploid chromosome number of $2n = 50$ (♀) and $2n = 51$ (♂). The autosomes are formed by 4 pairs of individually distinguishable metacentric and 20 pairs of telo- to acrocentric chromosomes. The last ones have very minute p-arms, and only in metaphases with long, slightly condensed chromosomes could the p-arms be identified. Satellites were sometimes visible in these metaphases at the end of the q-arms of some of the largest acrocentric chromosomes. No further grouping of the autosomes was possible after orcein staining (fig. 2).

The heterosomes are 2 submetacentric X-chromosomes in the female, and one X, a submetacentric Y1 and an acrocentric Y2 chromosome in the male. The X is the largest of all chromosomes, containing about 14 % of the total chromosome length. Its p:q ratio is just 1:2. The Y1, also with a p:q ratio of 1:2, was individually identifiable even after orcein staining alone. Y2 could not be distinguished from other acrocentrics of similar length after orcein staining.

C-banding reveals constitutive heterochromatine at the kinetochore regions of all the autosomes. Two pairs of telocentric chromosomes exhibited heterochromatine at their telomeres. Most striking was the observation of constitutive heterochromatine accumulated along the total length of the p-arms of the X and Y1 chromosome (fig. 3).



Fig. 2. Karyotype of *Gazella bennetti*, orcein stained

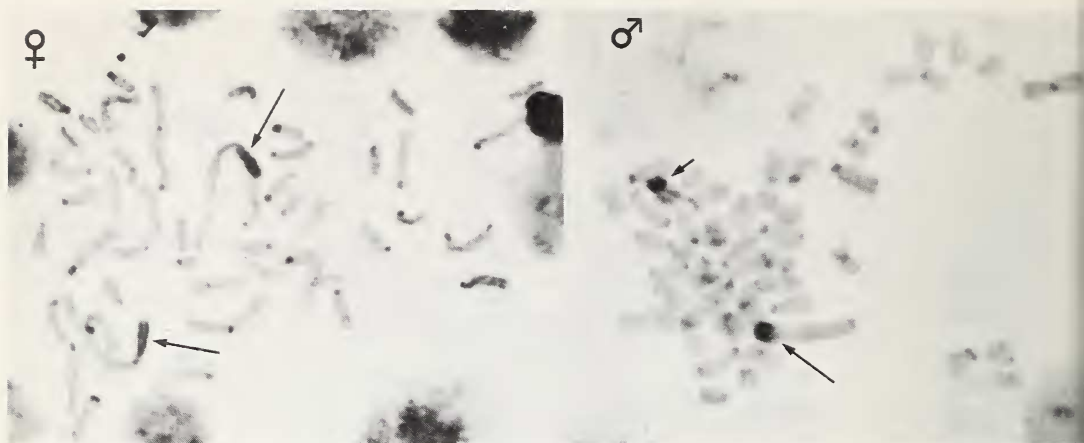


Fig. 3. C-banded chromosomes of a female and a male individual of *Gazella bennetti*. The arrows point to the heterochromatic arms of the X chromosomes and to the Y1 chromosome (short arrow)

Discussion

There are three points of interest in comparing the karyotype of *Gazella bennetti* with published karyotypes of other members of the genus *Gazella* (HSU and BENIRSCHKE 1967/77; WURSTER 1972; EFFRON et al. 1975; BENIRSCHKE et al. 1984): 1. the chromosome number, 2. the shape of the X and Y1 chromosomes with a p:q ratio of 1:2, and 3. the amount of constitutive heterochromatine in the p-arms of X and Y1 which all differ greatly from those previously described.

The high chromosome number of $2n = 50$ ♀/51 ♂ of *Gazella bennetti* is only outdone by $2n = 58$ in both sexes of *Gazella thomsoni* (HSU and BENIRSCHKE 1968). The autosomes of this species are all telo- to acrocentric. Of the other gazelles, *Gazella dama* with 38–40 chromosomes in the female and 39–40 in the male (BENIRSCHKE et al. 1984) is nearest to *Gazella bennetti*.

Varying chromosome numbers due to Robertsonian fusions/fissions in a zoo population of *Gazella soemmeringi* were published by BENIRSCHKE et al. (1984). In the case of *Gazella bennetti*, multiple fissions of different metacentrics may have lead to the numbers found in our investigations. Such a process could even have started from a chromosome number as low as the ones found in *Gazella granti* or *Gazella subgutturosa*. The 14 pairs of metacentrics of the latter species could be translated – by 10 fissions – into 4 remaining metacentrics and 20 acro- to telocentric pairs as observed in the investigated animals. A detailed analysis of the chromosomes by other banding techniques, which gives further evidence for this hypothesis, will be published separately. Because of the small number of individuals available, no comment is possible on the natural variation in chromosome numbers in *Gazella bennetti*.

The two other points of interest characterising the karyotypes of the investigated animals are of importance in considerations on the systematic position of *Gazella bennetti*. An X chromosome of comparable length with a similar p:q ratio is present in *Gazella subgutturosa*, *Gazella leptoceros*, *Gazella gazella*, *Gazella granti*, and *Gazella dama*. Only for the first three species have there been reports that the Xp behave heterochromatic. A